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Efficacy of interventions to increase physical activity for people with heart failure: a meta-analysis

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ABSTRACT

Objectives This meta-analysis aims to (1) evaluate the efficacy of physical activity interventions in heart failure and (2) to identify intervention characteristics significantly associated with the interventions' efficacy.

Methods Randomised controlled trials reporting intervention effects on physical activity in heart failure were combined in a meta-analysis using a random-effect model. Exploratory meta-analysis was performed by specifying the general approach (eg, cardiac rehabilitation), strategies used (eg, action planning), setting (eg, centre based), mode of delivery (eg, face to face or online), facilitator (eg, nurse), contact time and behavioural change theory use as predictors in the random-effect model.

Results Interventions (n=21) had a significant overall effect (SMD=0.54, 95% CI (0.13 to 0.95), p<0.0005). Combining an exercise programme with behavioural change intervention was found efficacious (SMD=1.26, 95% CI (0.26 to 2.26), p<0.05). Centre-based (SMD=0.98, 95% CI (0.35 to 1.62), and group-based (SMD=0.89, 95% CI (0.29 to 1.50),) delivery by a physiotherapist (SMD=0.84, 95% CI (0.03 to 1.65),) were significantly associated with efficacy. The following strategies were identified efficacious: prompts/cues (SMD=3.29, 95% CI (1.97 to 4.62)), credible source (standardised mean difference, SMD=2.08, 95% CI (0.95;3.22)), adding objects to the environment (SMD=1.47, 95% CI (0.41 to 2.53)), generalisation of the target behaviour SMD=1.32, 95% CI (0.22 to 2.41)), monitoring of behaviour by others without feedback (SMD=1.02, 95% CI (0.05 to 1.98)), self-monitoring of outcome(s) of behaviour (SMD=0.79, 95% CI (0.06 to 1.52), graded tasks (SMD=0.73, 95% CI (0.22 to 1.24)), behavioural practice/rehearsal (SMD=0.72, 95% CI (0.26 to 1.18)), action planning (SMD=0.62, 95% CI (0.03 to 1.21)) and goal setting (behaviour) (SMD=0.56, 95% CI (0.03 to 1.08)).

Conclusion The meta-analysis suggests intervention characteristics that may be suitable for promoting physical activity in heart failure. There is moderate evidence in support of an exercise programme combined with a behavioural change intervention delivered by a physiotherapist in a group-based and centre-based settings.

PROSPERO registeration CRD42015015280.

Key questions

What is already known about this subject?

► Individuals diagnosed with heart failure (HF) are advised to engage in physical activity. However, physical activity levels remain extremely low in this population group. Cardiac rehabilitation (CR) is routinely offered to newly diagnosed HF patients. CR is multifaceted; It is unknown which specific components result in physical activity improvements once the programme has ended. It is essential to understand how best to improve everyday physical activity engagement in HF.

What does this study add?

► This meta-analysis assessed what constitutes a successful physical activity intervention designed for individuals living with HF. The findings pinpoint specific intervention features and components that contribute to physical activity improvements in HF. Centre-based interventions that are delivered by a physiotherapist, in group format, which combine exercise with behavioural change intervention are promising for attaining physical activity improvements.

How might this impact on clinical practice?

► The findings of this meta-analysis may inform physical activity intervention designed for individuals diagnosed with HF. There is a need for additional training for physiotherapists in delivering behavioural change interventions alongside an exercise programme that includes the identified efficacious strategies.

INTRODUCTION

The levels of engagement in physical activity of medically stable individuals diagnosed with heart failure (HF) are low.[1] Physical activity is a treatment strategy.[2] Cardiac rehabilitation (CR) and other exercise-based programmes have been shown to improve quality of life (QoL)[3 4] and reduce hospitalisation in HF.[4 5] However, a recent meta-analysis suggested that CR is less likely to be efficacious in sustaining physical activity in HF in particular compared with other cardiovascular diseases (CVD).[6] The uptake of CR remains suboptimal.[7]

Therefore, it is essential to evaluate the efficacy of alternative interventions as well as CR and identify content and features that are likely to be successful in promoting physical activity.

CR is a complex intervention. It is unclear which components are responsible for what outcomes and for which patient group.[8] There is a need to explore this intervention complexity and identify what makes an intervention successful.[9] Past reviews have suggested that short-term intervention effects are associated with strategies such as exercise prescription; goal setting; feedback and problem solving; and the use of a behavioural change theory.[10]

CR might be missing some efficacious elements. Clark *et al* pointed out that previous healthcare services research has not emphasised CR's goal: how best to ensure that CVD patients benefit from a healthy lifestyle, including physical activity. Clark *et al* also made a call to evaluate a range of potentially effective interventions that are facilitated by various professionals and make use of a diverse set of methods (eg, remote monitoring). Evaluation of home-based and remote interventions is especially vital, given the recent restriction following the SARS-CoV-2 outbreak. It is also essential to understand what features of centre-based, group-based interventions contribute to physical activity improvement. The present meta-analysis of randomised controlled trials (RCTs) reviewed physical activity interventions, including CR, to identify intervention features that contribute to efficacy in improving physical activity.

METHODS

Information sources

The review protocol was registered on PROSPERO database (CRD42015015280). Cochrane Library, MEDLINE, CINAHL, EMBASE, AMED, HEED, PsycArticles, PsycINFO, Global Health, Web of Science: Conference Proceedings, 'Be Part of Research' and ClinicalTrials.gov were searched from inception to 20 February 2020. The search strategy is described in online supplemental material 1.

Eligibility criteria and study selection

Titles, abstracts and full texts were independently screened by two reviewers (AA and PW). The criteria for considering RCTs were: (1) adults diagnosed with HF, (2) intervention targeting physical activity (compared with usual care and/or education), and (3) report of a numerical result for physical activity outcome at intervention completion for both groups. Physical activity outcome was defined as any bodily movement produced by skeletal muscles that requires energy expenditure. Exercise is a subset of physical activity defined as structured physical activity.[11] Exercise, in the context of HF, is defined as selfcare behaviour (ie, 'I exercise regularly').

Data collection process

Relevant information was extracted from trial reports (article, online supplemental materials and protocols) using a standardised Cochrane data extraction form.[12]

Risk of bias in individual studies

The risk of bias at the study level was assessed using the Cochrane Collaboration Risk of Bias tool[2 13] and informed sensitivity analysis.

Data items

Interventions were classified in terms of their general approach to physical activity promotion (eg, exercise), setting (eg, home vs centre), mode of delivery (eg, group vs individual) and facilitator (eg, nurse). The Theory Coding Scheme (TCS)[14] was used to describe the extent to which trials employed a behavioural change theory in the intervention design. TCS scores range from 0 (no theory) to 8 (most extensive theory use). The intervention and comparator treatment were described in terms of the included behavioural change techniques. Interventions' content was independently annotated by AA (100%) and TF (61.90%) using the Behaviour Change Techniques Taxonomy (BCTTv1).[15]

Statistical analysis

Meta-analysis was performed using the metafor library in R.[16] A random-effect model was used to estimate the overall efficacy of interventions using restricted maximum likelihood. The standardised mean difference (SMD) in physical activity levels between the main intervention and the comparator group was selected as the estimate of efficacy. Heterogeneity index (I^2) was reported as the total unexplained variability in effect. Assessments at the 3 months, 6 months (short-term) and 12 months (long-term) follow-up were included. Meta-regression was performed to explore whether the efficacy was associated with the following: general approach (eg, exercise programme), setting, mode of delivery (eg, home-based), facilitator (eg, nurse), behavioural change strategies (eg, goal setting) and participant characteristics (ie, mean age, New York Heart Association (NYHA) class, proportion of males, mean ejection fraction (EF, %), aeschimic aetiology (%)) were specified as predictors in the model.[17] We accounted for the fact that a small number of trials were presenting a particular intervention characteristic using Hartung-Knapp-Sidik adjustment as recommended by Debray *et al*.[18]

Risk of bias across studies

The small study bias was evaluated using a funnel plot assessment and Egger's test.

Patient and public involvement

No patients were involved in formulating the research question, the outcome measures or findings interpretation. Patients were not involved in planning or designing of the meta-analysis. This is due to the lack of funding available to include patients as partners in this meta-analysis. Results of this meta-analysis will be disseminated to the relevant patient organisations.

RESULTS

Search results

Search results and reasons for exclusion are listed in the Preferred Reporting Items for Systematic Reviews and

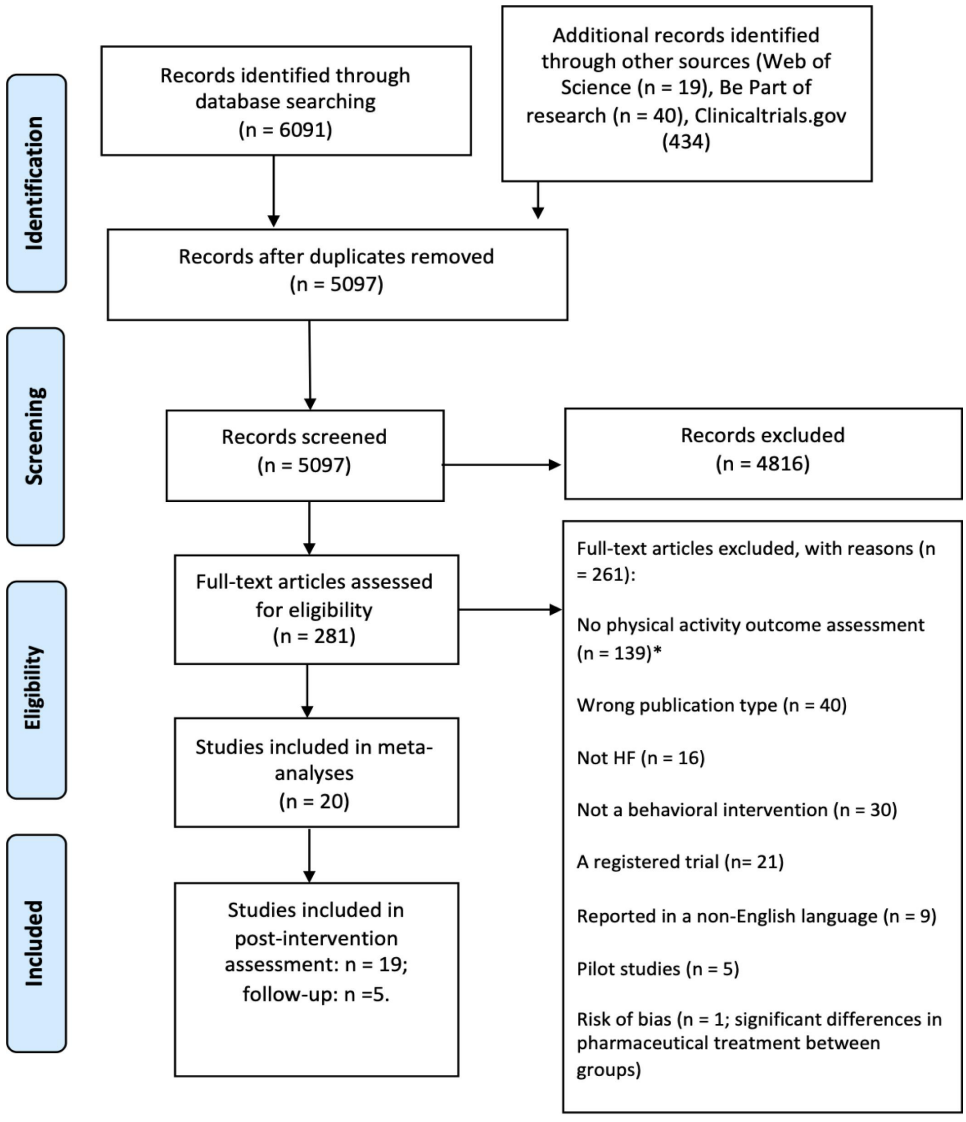

Figure 1 The study flow chart (PRISMA, 2009). HF, heart failure; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Meta-Analyses diagram (figure 1). A total of 20 trials evaluating 22 interventions postcompletion (n=21,[19–37]), at 6 months (n=5,[29 32 33 35 38]) and 12 months (n=5,[26 27 29 36–38]) follow-up were included in the meta-analysis.

Study characteristics

The trials were conducted between 1999 and 2018. The trials included a total of 6277 participants, and the median sample size was 100 (IQR: 60–204). A large proportion (37%) of participants were drawn from the HF-ACTION trial (n=2331).[37]

RISK OF BIAS

The overall risk of bias is summarised in figure 2. Six out of 20 trials reported low risk of bias.[20 22 26 27 29 37] A high risk of bias was present in two trials.[19 30] The sources of bias for each trial are summarised in online supplemental material 2. Five trials evaluated the intervention against an active comparator:education.[19 21 22 27 38]

Participant characteristics

Mean age ranged from 54[19] to 80 years old[33] (SD=7.28; IQR 62–70), and the majority of the sample was male 69.49% (table 1).

Postcompletion efficacy

The present meta-analysis found a significant overall effect as assessed at postcompletion (SMD=0.54, 95% CI (0.13 to 0.95), p<0.005). There was significant high heterogeneity in the estimated effect, I2=95.8%, (Q=1531.74, p<0.001) (figure 3). The following intervention characteristics contributed to the heterogeneity in efficacy:

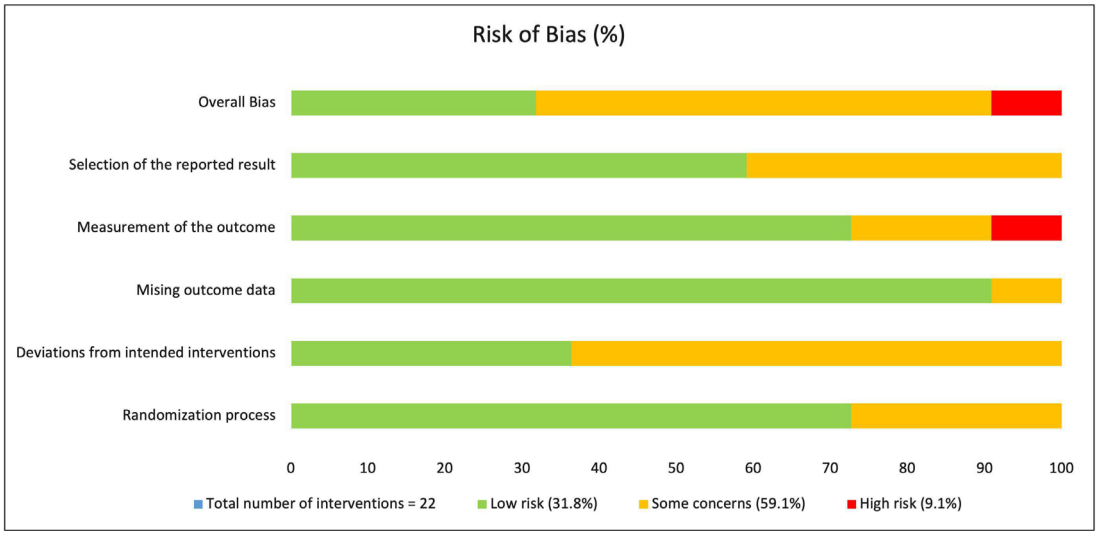

Figure 2 The risk of bias summary. The Cochrane Collaboration Risk of Bias tool (V.2).[15]

general approach of the interventions, setting (ie, centre based vs home based), facilitator and several strategies.

General approach

The included trials delivered interventions that were classified as exercise (k=10, 47.62%), exercise and behavioural change (k=3, 14.29%), motivational interviewing (k=2, 9.42%), remote communication and treatment (k=3, 14.29%), cognitive–behavioural therapy (k=1, 4.76%), disease management (k=1, 4.76%) and self-management (k=1, 4.76%) (table 2). Exercise combined with behavioural change is an efficacious approach (figure 4).

Intervention strategies

A total of 38 strategies (ie, behaviour change techniques, (BCTs)) were present across included trials (online supplemental material 4). Interventions included a mean of 8.90 (SD=3.77; IQR=8–10) strategies. The following strategies were associated with moderate to large effects: prompts/cues, credible source, adding objects to the environment, generalisation of target behaviour, monitoring of behaviour by others without feedback, self-monitoring of outcome(s) of behaviour, graded tasks, behavioural practice/rehearsal, action planning, goal setting (behaviour) (SMD: 0.56–3.29) (table 3).

Settings, facilitator and duration

Interventions were delivered at home (n=8, 38%), in a hospital/clinic (n=8, 38%), or both (n=5, 24%). Only centre-based delivery significantly moderated the efficacy of the included interventions (table 3). Interventions were facilitated by general practice nurses (n=9, 42.85%), physiotherapists (n=6, 28.6%), HF nurses (n=4, 19%), exercise instructors (n=3, 14.29%), researchers (n=2, 9.42%), lay leaders (n=1, 4.76%), advanced practice nurse (n=1, 4.76%), psychologists (n=14.76%), and clinical psychology trainees (n=1, 4.76%). Intervention delivery by a physiotherapist was associated with efficacy (table 3). Intervention duration varied from 1 day to 72 weeks. Mean contact time was 1849.38 min (SD=1716.40) and was not associated with intervention efficacy.

Theory use

Seven interventions were based on a behavioural change theory (online supplemental material 4). The extent of theory use (TCS) was not associated with efficacy (SMD=0.13, p=0.059, 95% CI (−0.006 to 0.27)).

Sample characteristics, including mean age, gender, mean left-venticular ejection fraction (LVEF, %), New York Heart Association (NYHA) class, and aetiology, were not significantly associated with intervention efficacy (online supplemental material 5). Likewise, the differences in efficacy between trials using self-reports and trials using accelerometer or pedometer were non-significant (online supplemental material 5).

Long-term efficacy

The included interventions assessed physical activity at a 2-month, 6-month, 12-month and 30-month follow-up. The overall short-term effect was non-significant at the 6 month, (SMD=0.06, 95% CI (−0.49 to 0.38), p=0.80) and 12-month follow-up, (SMD=−0.11, 95% CI (−0.77 to 0.55), p=0.80). Due to the small number of interventions reporting follow-up assessment, it was not feasible to evaluate the long-term effects associated with the individual intervention characteristics.

Sensitivity analysis

Interventions were compared with usual care,[20 23–26 28–30 33–37] education delivered by an HF specialist nurse[21 22 27 38] or unspecified health professional,[19] and discouragement to exercise.[32] The comparator treatments included a mean of 1.15 (SD=1.49) strategies (online supplemental material 4). When trials comparing the main intervention to education were excluded, the effects of exercise and behavioural change, remote monitoring and treatment, and

Table 1 Study and participant characteristics

Author, year	Country	No of participants		Assessment time points		Mean age, years (SD)	Male, %	LVEF, % (SD)	NYHA II-III, %	Physical activity‡ outcome
		Control	Intervention	Postintervention*	Follow-up†					
Ajiboye *et al*,[19] 2015	Nigeria	23	28	12 weeks	–	54 (1.6)	53.7	–	–	Self-reported physical activity (diary)
Bernocchi *et al*,[20] 2018	Italy	56	56	4 months	2 months	71(9)	88	44.5 (12.4)	45	Accelerometer (Average energy activity counts)
Boyne *et al*,[21] 2014	Netherlands	185	197	1 year	–	71 (11.9))	58	<40	29; 21	Exercise: Heart Failure Selfcare, Behaviour Scale (Jaarsma, Strömberg, Mårtensson, & Dracup, 2003)
Brodie *et al*,[22] 2005; 2008	UK	32	30 (MI and UC);30 (MI)	8 weeks	–	79 (6.9)‡	–	31.3 (5.9)§	28; 58	Self-reported general physical activity (Booth et al., 1996)
Collins *et al*,[23] 2004	UK	16	15	24 weeks	–	62.7 (11.2)	100	31.7 (6.9)	–	Self-reported physical activity (diary)
Corvera-Tindel *et al*,[24] 2004	USA	42	37	12 weeks	–	63.8 (10.1)	99	29.1 (8.5)	80; 20	Pedometer
Cowie *et al*,[25] 2013	UK	20	20 (Home); 20 (Hospital)	8 weeks	–	66 (35–85)¶	85	<40	62; 38	Accelerometer (Average energy activity counts)
Dalal *et al*,[26] 2019	UK	92	93	12 weeks	–	69.7 (10.9)	78	34.5 (25–39)¶	59	Accelerometer (Average energy activity counts)
Freedland *et al*,[27] 2015	USA	60	58	6 months	12 months	55.8 (11.2)‡	53.8	38.9 (15.5)‡	42.4	Accelerometer (Average energy activity counts)
Jolly *et al*,[36] 2009	UK	85	84	24 weeks	12 months	65.9 (12.5)	76	<40	75; 20	Self-reported physical activity (minutes per week, Godin Leisure-Time Exercise Questionnaire, (Godin & Shephard, 1985)
Meng *et al*,[38] 2013; 2016	Germany	227	248	–	6; 12 months	61.2 (11.7)	75	31.7 (7.0)	54.7	Self-reported physical activity (minutes per week, Godin Leisure-Time Exercise Questionnaire, (Godin & Shephard, 1985)
O'Connor *et al*,[37] 2009	USA (88.72%) Canada (8.07%) France (3.33%)	1172	1159	24 weeks	12; 30 months	59.2 (51.2–67.8)¶	72	<35	62; 36	Self-reported physical activity (diary)
Pozehl *et al*,[28] 2018	USA	102	102	18 months	–	60.4 (11.5)‡	56.0	39.4 (12.7)‡	91.2	Self-reported physical activity
Smeulders *et al*,[29] 2009	Netherlands	131	186	6 weeks	6;12 months	66.6 (11.0)	75.8	<40	64; 36	Self-reported physical activity
Tomita *et al*,[30] 2008	USA	13	19	1 year	–	74.2 (9.7)	32.5	–	75; 25	Self-reported physical activity
van den Berg-Emons *et al*,[31] 2004	Netherlands	16	18	12 weeks	–	58.6 (12.1)	81	23.9 (9.4)	56; 44	Accelerometer (Average energy activity counts)

Continued

Table 1 Continued

Author, year	Country	No of participants		Assessment time points		Mean age, years (SD)	Male, %	LVEF, % (SD)	NYHA II-III, %	Physical activity‡ outcome
		Control	Intervention	Postintervention*	Follow-up†					
Willenheimer *et al*,[32] 1998	Sweden	27	23	16 weeks	6 months	64 (5)	70	0.35 (0.11)	50; 36	Self-reported physical activity (The total physical activity score calculated using the following formula: Time spent on each activity per week intensity*2/100)
Witham *et al*,[33] 2005	UK	41	41	12 weeks	6 months	80 (6)	63	–	61; 39	Accelerometer (Average energy activity counts)
Yeh *et al*,[34] 2004	USA	50	50	12 weeks	–	68.1 (11.9)	56	28.3 (8.0)	62; 18	Self-reported physical activity (CHAMPS; Stewart 2001)
Young et al,[35] 2015; 2016	USA	49	51	3 months	6 months	68.7 (11.8)	47.1	53.4 (12.9)	29.4 ;56.9	Accelerometer (Average energy activity counts)
Meta-analysis sample:		**N (Control)=2555**	**N (Intervention)=3722**			**66 years IQR:(62–70)**	**Male (69.49 %) IQR:(56–78)**			

Physical activity outcome was defined as any bodily movement produced by skeletal muscles that requires energy expenditure (WHO, 2018). Exercise is a subset of physical activity defined as structured physical activity (WHO, 2018). In the context of HF, exercise is also defined as self-care behaviour (ie, 'I exercise regularly').
*Time from baseline.
†Time from intervention completion.
‡Mean for the total sample.
§Group 1: MI + UC; - not reported.
¶Median age (range).
HF, heart failure; MI, Motivational Interviewing; UC, usual care.

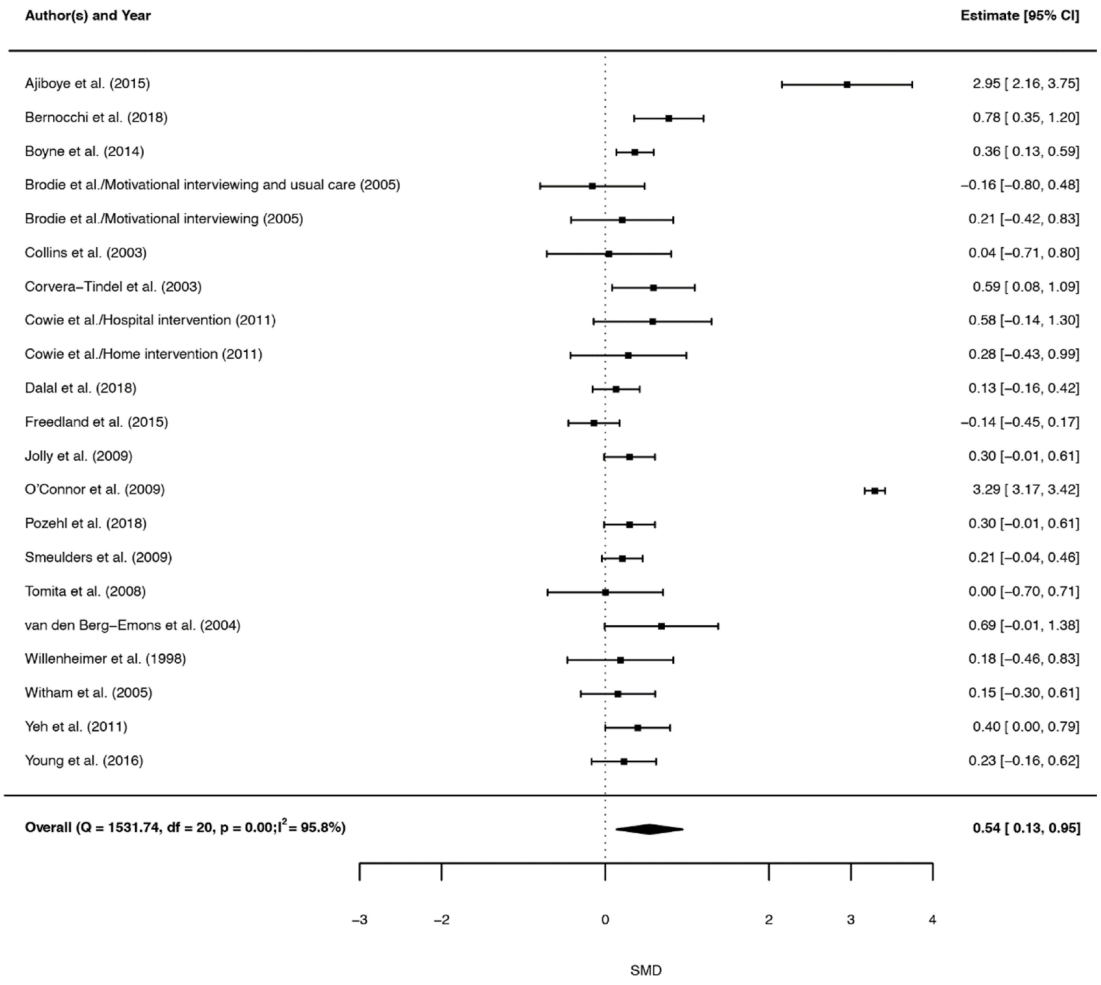

Figure 3 Forest plot illustrating overall estimated effect (SMD) and 95% CI and SMD and 95% CI for component trials. SMD, standardised mean difference.

exercise were significant (online supplemental material 6). The exclusion of a large (N=2331) trial with a younger (56 years old) sample[37] resulted in a significant decrease in the overall effect. The effect estimates for exercise and behavioural change approach, prompts/cues, credible source, adding objects to the environment, generalisation of the target behaviour, monitoring of behaviour by others without feedback, self-monitoring of outcome(s) of behaviour, action planning, and goal setting (behaviour) were sensitive to the inclusion of the trial (online supplemental material 6). The exclusion of interventions with a high risk of bias indicated that the efficacy of *Exercise* approach was overestimated. The effects of the following strategies were underestimated*:* social support (emotional), social support (practical), theory use (TCS score), information about health consequences and information on how to perform the behaviour.

Small study bias

A funnel plot for SMD against SE is available in online supplemental material 7. The Egger's test suggested a lack of publication and small study bias (test for funnel plot asymmetry: $Z = 0.46$, $p = 0.46$)

DISCUSSION

The present meta-analysis found moderate evidence in support of existing physical activity interventions designed for individuals living with HF. Centre-based interventions that are delivered by a physiotherapist, in group format, which combine exercise with behavioural change intervention are promising for attaining physical activity improvements. Intervention strategies identified as efficacious are: prompts/cues, credible source, adding objects to the environment, generalisation of the target behaviour, monitoring of behaviour by others without feedback, self-monitoring of outcome(s) of behaviour, graded tasks, behavioural practice/rehearsal, action planning, and goal setting (behaviour). To our knowledge, this is the first meta-analysis evaluating the components of behavioural interventions that are associated with increased physical activity in HF. Interventions that were delivered by a physiotherapist in a centre-based setting were more promising in attaining physical activity improvement than home-based interventions or those delivered by facilitators other than physiotherapist (ie, nurse, lay leader, researcher). This is in contrast to the findings of a previous meta-analysis suggesting that

Table 2 Intervention characteristics

Author, year		Intervention description provided by authors	General approach
Ajiboye *et al*,[19] 2015	Main intervention	Aerobic and resistance training and education	Exercise
	Comparator treatment	Usual care and education	
Bernocchi *et al*,[20] 2018	Main intervention	Telerehabilitation and home-based personalised exercise maintenance programme	Remote communication and treatment
	Comparator treatment	Usual care	
van den Berg-Emons *et al*,[31] 2004	Main intervention	Aerobic exercise training	Exercise
	Comparator treatment	Usual care without particular advice for exercise	
Boyne *et al*,[21] 2014	Main intervention	Individually tailored e-health intervention 'Health Buddy'.	Remote communication and treatment
	Comparator treatment	Education	
Brodie *et al*,[22] 2005	Main intervention 1	Motivational Interviewing	Motivational interviewing
	Main intervention 2	Motivational Interviewing and education	
	Comparator treatment	Education	
Collins *et al*,[23] 2004	Main intervention	Aerobic exercise training	Exercise
	Comparator treatment	Usual care	
Corvera-Tindel *et al*,[24] 2004	Main intervention	A home walking exercise programme	Exercise
	Comparator treatment	Usual care	
Cowie *et al*,[25] 2011	Main intervention 1	Hospital-based aerobic exercise training	Exercise
	Main intervention 2	Home-based exercise training	
	Comparator treatment	Usual care	
Dalal *et al*,[26] 2019 (REACH-HF)	Main intervention	Rehabilitation enablement in HF: self-care and rehabilitation	Exercise and behavioural change
	Comparator treatment	Usual care	
Freedland *et al*,[27] 2018	Main intervention	Integrative cognitive–behavioural therapy and education and usual care	Cognitive–behavioural therapy
	Comparator treatment	Enhanced (with education) usual care	
O'Connor *et al*,[37] 2009 (HF-ACTION)	Main intervention	Aerobic exercise training and Exercise adherence facilitation intervention	Exercise and behavioural change
	Comparator treatment	Usual care	
Jolly *et al*,[36] 2009	Main intervention	Aerobic and resistance exercise training	Exercise
	Comparator treatment	HF specialist nurse care	
Meng *et al*,[38] 2016	Main intervention	Self-management patient education programme and CR	Self-management
	Comparator treatment	Education	
Pozehl *et al*,[28] 2018 (HEART Camp)	Main intervention	Multicomponent intervention and resistance exercise training	Exercise and behavioural change
	Comparator treatment	Enhanced (nine exercise sessions for 3 months)	
Smeulders *et al*,[29] 2009	Main intervention	Chronic disease management programme	Disease management
	Comparator treatment	Usual care	
Tomita et al,[30] 2008	Main intervention	Multidisciplinary internet-based programme on HF management	Remote communication and treatment
	Comparator treatment	Usual care	
Willenheimer *et al*,[32] 2001	Main intervention	Aerobic exercise training	Exercise
	Comparator treatment	Usual care and discouragement to exercise	
Witham *et al*,[33] 2005	Main intervention	Seated aerobic and resistance exercise training	Exercise

Continued

Table 2 Continued

Author, year		Intervention description provided by authors	General approach
	Comparator treatment	Usual care	
Yeh *et al*,[34] 2011	Main intervention	Exercise training (Tai Chi Mind-Body movement)	Exercise
	Comparator treatment	Usual care	
Young *et al*[35] 2015; 2016	Main intervention	Patient Activation Intervention on self-management in HF	Self-management
	Comparator treatment	Usual care	

CR, cardiac rehabilitation; HF, heart failure.

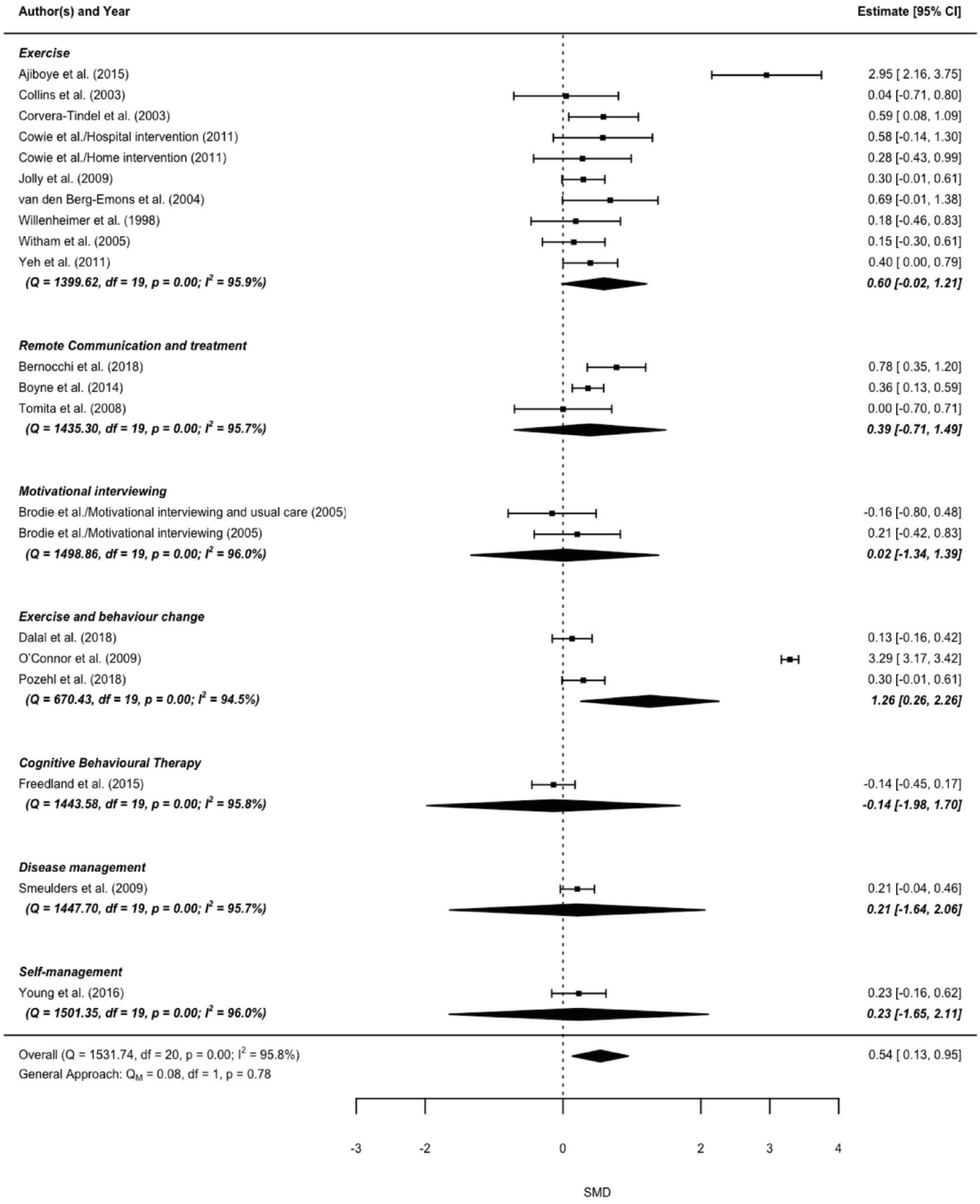

Figure 4 Forest plot illustrating the standardised mean differences (SMD, 95% CI) moderated by the general approach.

Table 3 Intervention characteristics associated with efficacy

Intervention characteristics	SMD	95% CI
Behavioural change techniques:		
Prompts/cues	3.29	(1.97 to 4.62)
Definition: Introduce or define environmental or social stimulus to promote or cue the behaviour. Examples: frequent phone calls by a health professional/ post or email reminders		
Credible source	2.08	(0.95 to 3.22)
Definition: resent verbal or visual communication from a credible source in favour of or against the behaviour. Examples: Explicit, detailed and salient advice from a health professional to engage in physical activity.		
Adding objects to the environment	1.47	(0.41 to 2.53)
Definition: Add objects to the environment in order to facilitate the performance of the behaviour. Examples: Provision of a treadmill, weights, step, or stationary bicycle.		
Generalisation of the target behaviour	1.32	(0.22 to 2.41)
Definition: Advice to perform the desired behaviour, which is already performed in a particular situation, in another situation. Examples: Encouragement to engage in an exercise in home settings.		
Monitoring of behaviour by others without feedback	1.02	(0.05 to 1.98)
Definition: Observe or record behaviour with the person's knowledge as part of a behavioural change strategy. Examples: The physiotherapist informs participants that their physical activity levels will be monitored using accelerometers and telemonitoring devices.		
Self-monitoring of outcome(s) of behaviour	0.79	(0.06 to 1.52)
Definition: Establish a method for the person to monitor and record the outcome(s) of their behaviour as part of a behavioural change strategy. Examples: Monitoring reduced pain symptoms and dyspnoea as a result of physical activity.		
Graded tasks	0.73	(0.22 to 1.24)
Definition: Set easy-to-perform tasks, making them increasingly difficult, but achievable until the behaviour is performed. Examples: Gradual increase in the level of exertion as assessed using the Borg scale.		
Behavioural practice/rehearsal	0.72	(0.26 to 1.18)
Definition: Prompt practice or rehearsal of the performance of the behaviour one or more times in a context or at a time when the performance may not be necessary. Examples: Exercise training (individual or in a group).		
Action planning	0.62	(0.03 to 1.21)
Definition: prompt, detailed planning of performance of the behaviour (must include at least one of context, frequency, duration and intensity). Examples: plan when, where, how much and at what intensity the participant will perform the exercise.		
Goal setting (behaviour)	0.56	(0.03 to 1.08)
Definition: set or agree on a goal defined in terms of the behaviour to be achieved. Examples: Set a goal to complete 30 min of exercise (brisk walking) at the vagarious intensity in future.		
Setting: Centre-based interventions	0.98	(0.35 to 1.62)
Mode of delivery: Group-based interventions	0.89	(0.29 to 1.50)
Facilitator: Physiotherapist	0.84	(0.03 to 1.65)

Definitions are from Michie *et al*.[15] Intervention characteristics are described in table 2 and online supplemental material 4. SMD and 95% CI for characteristics that were not suggested to be significantly associated with efficacy are summarised in online supplemental material 4.
SMD, standardised mean difference.

centre-based and home-based programmes delivered to individuals post-myocardial infarction or revascularisation, and with HF are equivalent in their efficacy in improving survival, QoL and exercise capacity.[39] The present meta-analysis found that delivery of an intervention to a group contributed to efficacy. However, given the ongoing pandemic, it is essential to optimise delivery of physical activity interventions in home settings. Group-based interventions contribute to behavioural change via social comparison, changes in normative beliefs about health behaviour and group member identity.[40] These factors can also be considered when designing home-based, contact-free physical activity interventions for older adults with HF.

A previous systematic review of CR programmes found that, in general, educational and behavioural elements of CR did not result in physical activity improvements beyond those achieved by exercise-based programmes.[6] However, behavioural elements are diverse and vary in their efficacy. The present meta-analysis evaluated a range of such elements and outlined those that are efficacious. A combination of an exercise and behavioural change approach was found to be more efficacious than other approaches, including exercise alone. Several

strategies to improve physical activity appear promising (table 3). Theoretical explanations for the efficacy of these strategies were previously offered.[41] Graded tasks exert an effect on physical activity by fostering positive beliefs about capability through skill mastery (eg, exercise training).[41] Self-monitoring, monitoring by others, planning, goal-setting and feedback are theorised to improve control and regulation of behaviour.[42] Finally, the efficacy of adding an object associated with physical activity (eg, treadmill) indicates the relevance of cueing (ie, automatic association and non-deliberate regulation of behaviour).[41]

Implications for clinical practice and future research

The present meta-analysis found moderate evidence in support of combining exercise programme with behavioural change intervention, delivered by a physiotherapist. Thus, there is a need for additional training for physiotherapists in delivering behavioural change interventions that will include the identified efficacious strategies. Practical limitations of the identified efficacious strategy need to be considered when designing interventions. Adding objects to the environment to support physically activity lifestyle (eg, a treadmill) may not be affordable or practical, and does not satisfy the principle of health equity.[43] In addition, further research investigating how best to promote a physically active lifestyle in the older HF population is encouraged. The clinical profiles of older adults differ from younger adults, with a significantly worse prognosis and a larger number of comorbidities in the former.[44] Older adults may also differ in their beliefs about physical activity; and strategies that are suited for promoting an active lifestyle in older adults are different to those that are efficacious for the general population.[45] Investigation of which behavioural change theory should form the basis for an intervention is also warranted. Only five trials assessed physical activity at 6-month and 12-month follow-ups. Long-term efficacy was not supported. Thus, it is important to investigate how sustained physical activity improvements can be established.

Study-level limitations

High risk of bias was observed in two trials.[21 32] The sensitivity analysis indicated that the inclusion of these trials may overestimate the efficacy of exercise programmes and underestimate the efficacy of remote monitoring and treatment. Remote communication and feedback interventions that include strategies such as biological feedback (eg, symptom monitoring and feedback) delivered by a nurse using telehealth device, as well as self-monitoring of the behaviour and information about health consequences[22 23] are identified as efficacious when high risk of bias trials are excluded. The HF-ACTION[37] trial constituted the majority of the meta-analysis sample and when it was excluded in the sensitivity analysis, only a small non-significant effect of exercise combined with behavioural change was observed. High-quality trials assessing the short and long-term effects of behavioural change; remote communication and treatment; and exercise programmes on physical activity in older adults (>70 years old) with HF are required.

Strengths and limitations of the review

A Cochrane overview of reviews recommended exploring intervention complexity using meta-regression to evaluate the association between intervention characteristics and efficacy.[9] This meta-analysis identified, annotated and classified behavioural change interventions in terms of their general approach, strategies, settings, facilitator, delivery mode, duration and use of theory; and using meta-regression assessed the association between these characteristics and the efficacy. The clear, consistent and systematic description of the interventions facilitated the reliable grouping and analysis. This helped pinpoint specific efficacious features and elements that can be applied, either as part of CR or otherwise, to improve physical activity outcomes in HF. However, there are a few limitations. Intervention features were present in clusters across the included trials. Given the small number of RCTs evaluating any single included characteristic, multiple comparisons were not feasible. It is not possible to ascertain whether each of the evaluated features is efficacious on their own or only in combination. These features need to be evaluated in a multiarm trial comparing their effects.

CONCLUSIONS

This meta-analysis explored intervention complexity and identified some features of potentially promising physical activity interventions designed for people living with HF. The present review provides moderate evidence that an exercise programme combined with a behavioural change intervention is a promising approach to increasing physical activity in HF. The meta-analysis suggests behavioural change strategies that may be useful in promoting physical activity in HF.

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Supplement 1. Search strategy

A. Search Strategy (Interface - EBSCOhost Research Databases):

OR/1-22: (MM "Heart Failure+"), "heart failure", (MM "Cardiac Output, Decreased"), (MM "Ventricular Dysfunction+"), heart N5 fail*, cardi* N4 dysfunction*, heart N5 dysfunction*, "congestive heart failure", "cardiac fail*", "systolic heart failure", "cardiac incompetence" , "cardiac decompensation", "cardiac insufficiency", "chronic heart failure", "cardial insufficiency", "myocardial failure", "myocardial insufficiency", "heart N3 fail*", "diastolic dysfunction*", "Systolic dysfunction*", "heart N3 dysfunction*", "cardiac dysfunction*".

OR/24-46: (MH "Behavioral Changes"), (MH "Life Style Changes") , (MM "Self Care+") , "Self-management",“Intervention”, (MM "Early Intervention+") , (MM "Patient Care+") , (MM, "Rehabilitation+"), (MM "Home Rehabilitation+") , (MM "Rehabilitation, Cardiac+") , (MM "Rehabilitation, Community-Based"), (MH "Physical Education, Adapted"), (MH "Behavioral Objectives"), (MH "Psychosocial Adjustment: Life Change (Iowa NOC), (MH "Change Management") , (MH "Behavior Management (Iowa NIC)"), (MH "Health Behavior") , (MH "Phychotherapy+"), "Behavio$ral intervention", "Behavio$change technique*", "Behavio$r change", "Counselling", "Psychotherapy".

OR/48-62: (MH "Physical Activity"), (MH "Sports+"), (MH "Activities of Daily Living+"), (MH "Exercise+"), (MH "Leisure Activities+"), (MH "Physical Fitness+"), (MH "Movement"), (MH "Aerobic Exercise+"), (MH "Swimming"), (MH "Rehabilitation, Cardiac"), (MH "Resistance training"), (MH "Sports Specific Training"), (MH "Group Exercise"), Physical N5 activ*, Exercis*.

OR/64-66: (MH "Randomized Controlled Trials"), "Randomi$ed controlled trial", "Clinical trial".

23 AND 47 AND 63
23 AND 47 AND 63 AND 67

B. Search Strategy (Interface - OVID):

1. exp heart failure/
2. heart failure.mp.
3. heart decompensation.mp.
4. heart insufficiency.mp.
5. cardiac failure.mp.
6. cardiac incompetence.mp.
7. cardiac decompensation.mp.
8. cardiac insufficiency.mp.
9. exp heart output/
10. cardiac output.mp.
11. exp diastolic dysfunction/
12. exp congestive heart failure/
13. diastolic dysfunction.mp.
14. exp systolic dysfunction/
15. exp heart left ventricle failure/
16. heart left ventricle failure.mp.
17. cardial insufficiency.mp.
18. chronic heart failure.mp.
19. chronic heart insufficiency.mp.
20. decompensation,heart.mp.
21. myocardial failure.mp.
22. myocardial insufficiency.mp.
23. (heart adj3 fail*).tw.
24. (heart adj3 dysfunction*).tw.
25. left ventricular dysfunction.tw.
26. (cardiac adj3 dysfunction*).tw.
27. (cardiac adj3 fail).tw.
28. ventricular dysfunction.mp.
29. chronic cardiac failure.mp.
30. congestive cardiac failure.mp.
31. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30

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32. exp physical activity/
33. physical exercise.mp.
34. physical activity.mp.
35. exercise.mp.
36. exp aerobic exercise/
37. aerobic exercise.mp.
38. exp resistance training/
39. resistance training.mp.
40. exercise training.mp.
41. exp daily life activity/
42. exp walking/
43. exp motor activity/
44. daily physical activity.mp.
45. exp motor activity/
46. exp leisure/
47. leisure activities.mp.
48. exp heart rehabilitation/
49. cardiac rehabilitation.mp.
50. exercise program.mp.
51. exercise programme.mp.
52. exp fitness/
53. exp swimming/
54. exp sport/
55. exp endurance training/
56. (physic* adj3 activ*).tw.
57. physical activity.tw.
58. exercis*.tw.
59. walk*.tw.
60. (daily adj5 physic adj5 activ*).tw.
61. 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60
62. 31 and 61
63. exp intervention study/
64. intervention.mp.
65. exp health promotion/
66. exp behavior change/
67. behavioral intervention.mp.
68. behaviour change.mp.
69. exp behavior change/
70. psychological intervention.mp.
71. exp patient education/
72. exp counseling/
73. exp patient counseling/
74. behav* change.tw.
75. (change adj3 behavio$r).tw.
76. intervention.tw.
77. health promotion.tw.
78. behavio$r change technique*.tw.
79. behavio$r change strateg*.tw.
80. BCT.tw.
81. randomized controlled trial.tw.
82. randomized controlled trial/
83. clinical trial/
84. controlled study/
85. RCT.mp.
86. 81 or 82 or 83 or 84 or 85
87. cardiac rehabilitation.tw.
88. 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 87
89. 31 and 61 and 86 and 88

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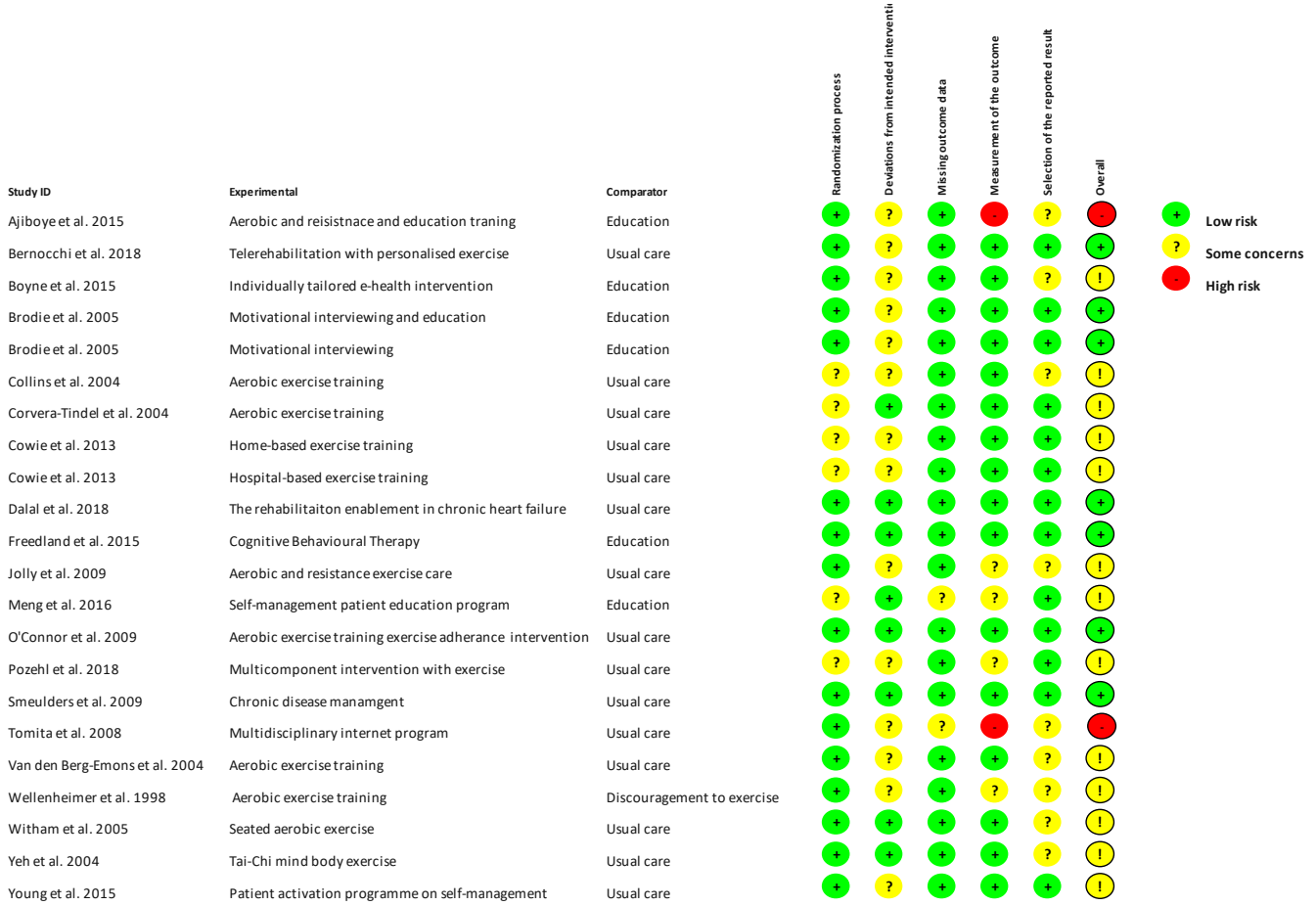
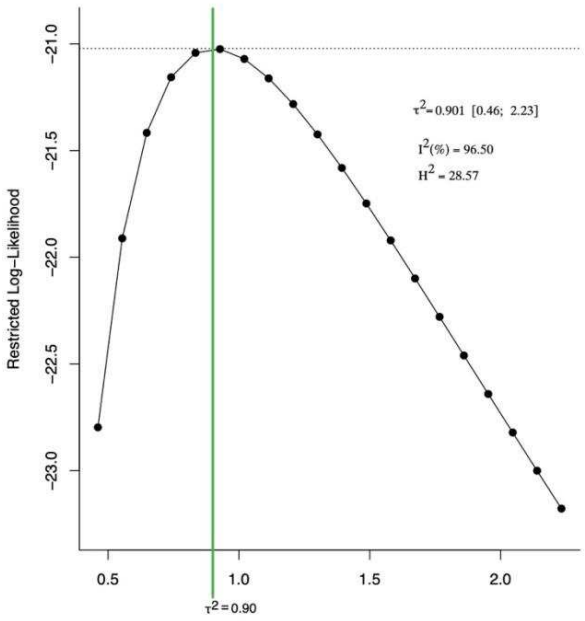
Supplement 2. Risk of bias: individual studies



TITLE: Efficacy of interventions to increase physical activity for people with heart failure: a meta-analysis

Supplement 3. The dispersion of the underlying main effect



The dispersion (tau) of the underlying main effect.

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Supplement 4. Intervention characteristics (expanded Table 2)

Author, year		Intervention description	Behaviour Change Techniques	Intervention intensity	Facilitator	mode of delivery	Theory (TCS)
Ajiboye et al., 2015	*Main intervention*	Aerobic and resistance training and education	BP/R; GT	36 session; 60-minute sessions; three a week (36 sessions)	nr	face-to-face	none
	Comparator treatment	usual care and education	PI				
Bernocchi et al., 2018	*Main intervention*	integrated telerehabilitation home-based programme (Telereab- HBP) with personalised exercise maintenance programme	IHC; CS: IHPB; AOE; BP/R; GT; SMB; MbBOwF; FB;	nr	Nurse tutor; physiotherapist tutor	telemonitoring of vital signs. Mini-ergometer, pedometer and diary.	none
	Comparator treatment	usual care	IHC				
van den Berg-Emons et al., 2004	*Main intervention*	aerobic exercise training	AP; BP/R; GS(B);	24 sessions, 60-minute sessions twice a week (12 weeks)	not reported	hospital-based training in groups	none
	Comparator treatment	usual care without particular advice for exercise	none	not reported	not reported	not reported	none

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Author, year		**Intervention description**	**Behaviour Change Techniques**	**Intervention intensity**	**Facilitator**	**mode of delivery**	**Theory (TCS)**
Boyne et al., 2014	*Main intervention*	Individually tailored e-health intervention 'Health Buddy.'	IHC; SMB; SMOB	364 sessions: daily 10-minute session (52 weeks)	HF nurse and a nurse assistant	Telemonitoring device 'Health Buddy.'	none
	Comparator treatment	education	IHC	not reported	not reported	Home-based, individual	none
Brodie et al., 2005	*Main intervention*	Motivational Interviewing	GT; IHC; PS; SC; SMB; SS(E); SS(U);	Eight sessions: Weekly 60- minute sessions (8 weeks)	A researcher without clinical qualification	home-based Face-to-face sessions	MI (TCS = 2)
	Main intervention	Motivational interviewing + education	GT; PS; SC; SMB; SS(E); SS(U)	Eight sessions: Weekly 60- minute sessions (8 weeks)	HF specialist nurse; researcher without clinical qualification	home-based Face-to-face sessions + Usual care package	MI (TCS = 2)
	Comparator treatment	education	IHC	not reported	HF specialist nurse	Usual care package	none
Collins et al., 2004	*Main intervention*	Aerobic exercise training	AOE; AP; BP/R; GS(B); GT; IHPB; RP/C	120 sessions five days a week 50 minutes (24 weeks)	Exercise physiologist or nurse	Supervised group-based	none

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Author, year		Intervention description	Behaviour Change Techniques	Intervention intensity	Facilitator	mode of delivery	Theory (TCS)
	Comparator treatment	usual care	none	not reported	not reported	not reported	none
Corvera-Tindel et al., 2004	*Main intervention*	A home walking exercise programme	BP/R; GS(B); GT; MBbOwF; MOBwF; SMB	60 sessions: 60 minutes 5 days a week (12 weeks)	nurse	Home-based, Supervised	none
	Comparator treatment	usual care	MBbOwF	not reported	not reported	not reported	none
Cowie et al., 2011	*Main intervention*	hospital-based aerobic exercise training	Intervention 1: AP; BP/R; DB; GS(B); GT; IHC; IHPB; RBG; SMB; SMOB;	16 sessions: 60 minutes sessions, Twice a week eight weeks	Exercise instructor	Face-to-face, hospital-based	none
	Main intervention	home-based exercise training	Intervention 2: AP; BP/R ; DB; GS(B); GT; GTB: IHC; IHPB: SMOB;	16 sessions: 30 minutes sessions, Twice a week eight weeks	physiotherapist	home-based, individual (DVD)	none
	Comparator treatment	usual care	none	not reported	not reported	not reported	none

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Author, year		Intervention description	Behaviour Change Techniques	Intervention intensity	Facilitator	mode of delivery	Theory (TCS)
Dalal et al., 2018 (REACH-HF)	*Main intervention*	the Rehabilitation Enablement in Chronic Heart Failure (REACH-HF) self-care and rehabilitation intervention	BP/R; RNE; RPE; IHC; SS(E); SS(P); SS(U); GT; GS; PS; RBG; SMB	at least three face-to-face sessions; via phone - unspecified; 12 weeks	Two trained cardiac nurses	nr	SDT, CSM, CT (TCS = 5)
	Comparator treatment	usual care	IHC				
Freedland et al., 2018	*main intervention*	Integrative Cognitive Behaviour Therapy + Enhanced (with education) usual care	IHC; GS(B); AP; CS; IHPB; PS; MBOwF; MOBwF; ST; PC;	25 sessions; 60-minute sessions; once a week; 4 education sessions via phone (30 minutes)	Clinical phycology trainee (graduate student)	nr	CBT (TCS = 6)
	Comparator treatment	Enhanced (with education) usual care	IHC	Four education sessions via phone (30 minutes)	Nurse	nr	none
O'Connor et al., 2009 (HF-ACTION)	*Main intervention*	Aerobic exercise training + Exercise adherence facilitation intervention	AOE; AP; BP/R; CS; GS(B); GT; GTB; IHC; IHPB; PC; SMB; SMOB; SS(E); MBbOwF; SS(P); SS(U)	72 sessions, three sessions per week (24 weeks)	Physiotherapist	Facility-based group-based exercise training	TTM, SCT (TCS = 7)
	Comparator treatment	usual care	CS; GS(B); IHC; MBbOwF; SS(U);	not reported	not reported	not reported	none

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Author, year		**Intervention description**	**Behaviour Change Techniques**	**Intervention intensity**	**Facilitator**	**mode of delivery**	**Theory (TCS)**
Jolly et al., 2009	*Main intervention*	Aerobic and resistance exercise training	AP; BC; BP/R; DB; GS(B); GT; IHC; IHPB SMB; SS(U)	Three supervised exercise sessions; 3 home visits; 3 telephone sessions; 120 self-applied sessions (5 times a week) 20-30 minutes (24 weeks)	PA instructor	Home-based, face-to-face	none
	Comparator treatment	HF specialist nurse care	IHC	not reported	HF specialist nurse	not reported	none
Meng et al., 2016	*Main intervention*	self-management patient education program + inpatient cardiac rehabilitation	IHC; GS(B); AP; PS; RBG; SMB; FPS; IHPB; BF	Five sessions; 60-75 minutes; 2 sessions a week (approx), three-week session;	Physician; nurse; psychologist; physiotherapist	face-to-face	**nr**
	Comparator treatment	education	IHC	One session; 60 minutes	physician	face-to-face	
Pozehl et al., 2018 (HEART Camp)	*Main intervention*	multicomponent intervention Heart Failure Exercise and Resistance Training (Heart Camp)	IHTB; BP/R; BF; IEC; iHC; MOBwF; SS(U); GS(B); RBG; PS; VPaC; FB; BF; SMB	Six group-based educational sessions (adoption: 6 and months), self-administered (maintenance at 13-18 months) one session a week (18 months)	coach trainer	nr	SCT (TCS = 5)

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Author, year		Intervention description	Behaviour Change Techniques	Intervention intensity	Facilitator	mode of delivery	Theory (TCS)
	Comparator treatment	Enhanced (nine exercise sessions for three months)	IHPB; BP/R	nr	nr	face-to-face	none
Smeulders et al., 2009	*Main intervention*	Chronic disease management programme	AP; BC; BE; BP/R; D; DB; FB; IHC; ISRM; PS; R; RNE; SS(U); ST	Six sessions 150 minutes once a week (6 weeks)	Lay leader (HF patient); HF specialist nurse	Hospital-based group-based exercise training and classes	SLT (TCS = 8)
	Comparator treatment	usual care	none	not reported	HF specialist nurse	not reported	none
Tomita et al., 2008	*Main intervention*	Multidisciplinary Internet-based programme on management of HF	FB; IHC; IHPB; SMB	Forty-two sessions, 3.5 sessions a month for about 10 minutes. 1-year e-health intervention	Self-applied (Website)	Home-based, internet-based (website)	TTM, SST (TCS = 2)
	Comparator treatment	Usual care	none	not reported	not reported	not reported	
Willenheimer et al ., 2001	*Main intervention*	Aerobic exercise training	AP; BP/R; DB; GS(B); GT; IHPB	41 session: 2 sessions a week (15 minutes) for seven weeks: and then three sessions a week (45 minutes) for nine weeks	physiotherapist	Hospital-based, Group-based exercise training	none

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Author, year		Intervention description	Behaviour Change Techniques	Intervention intensity	Facilitator	mode of delivery	Theory (TCS)
	Comparator treatment	usual care + discouragement to exercise	PI	16 weeks	nr	not reported	none
Witham et al., 2005	*Main intervention*	Seated aerobic exercise training followed by seated resistance exercise training	BP/R; GS(B); GT; GTB; IHC; MOBwF; SMB; SS(U)	17-20 sessions 20-minute session Twice a week (12 weeks)	Physiotherapist	Group-based, hospital-based exercise training (supervised and home settings) Followed by home self-monitoring, self-monitoring and goal setting.	none
	Comparator treatment	usual care	IHC	nr	nr	not reported	none
Yeh et al., 2011	*Main intervention*	Exercise training (Tai Chi Mind-Body movement)	AP; BC; BP/R; DB; GS(B); IHPB; SMB	twice a week (group sessions); three times a week home sessions) one hour (group sessions); 35 minutes (home sessions) (12 weeks)	Exercise instructor	Hospital-based, Group-based exercise training	none

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Author, year		Intervention description	Behaviour Change Techniques	Intervention intensity	Facilitator	mode of delivery	Theory (TCS)
	Comparator treatment	usual care	none	Not reported	Video recording	Followed by home-based exercise training and monitoring	none
Young et al. 2015; 2016	*Main intervention*	Patient Activation Intervention on self-management in HF (Patient AcTivated Care at Home: PATCH)	IHC; DB; IHPB; SMOB; ;GS(B); IAwCB; SC; VC; MBbOwF; NSI	12 sessions (45 minutes); one in a hospital and then twice a week for the first two weeks, once a week for weeks 3–6, and every other week for weeks 7–12 (12 weeks)	Advanced practice nurse	one session face-to-face; telephone	none
	Comparator treatment	Usual care	IHC	50-minute one session	nurse	face-to-face	none

Note: TCS – Theory Coding Scheme; nr – not reported; MI – Motivational Interviewing, SDT – Self-determination theory; CSM -- CT—Control Theory; CBT—Cognitive Behavioural Therapy; TTM – Transtheoretical Model of Change; SCT—Social Cognitive Theory; SLT – Social Learning theory; SST; AOE – 12.5. Adding objects to the environment; AP – 1.4. Action planning; BC –12.6. Body changes; BE – 4.4. Behavioural experiments: BP/R – 8.1. Behavioural practice/rehearsal; BF - Biofeedback; CS – 9.2. Credible source; D – 12.4. Distraction; DB – 6.1. Demonstration of the behaviour;FB – 2.2. Feedback on behaviour; FPS - 15.3. Focus on past success; GS(B) – 1.1. Goal setting (behaviour); GT – 8.7. Graded tasks; GTB – 8.6. Generalisation of target behaviour; IEC - 5.6. Information about emotional consequences; IHC – 5.1 Information about health consequences; IHPB – 4.1. Instruction on how to perform the behaviour; IAwCB – 13.5. Identity associated with changed behaviour; ISRM – 13.1. Identification of self as a role model; MBbOwF - 2.5. Monitoring of behaviour by others without feedback; MOBwF – 2.5. Monitoring of outcomes of behaviour without feedback; NSI – non-specific incentive; PC – 7.1. Prompts/cues; PS – 1.2. Problem-solving; R – 4.3. Reattribution; RBG – 1.5. Review behaviour goal(s); RNE –11.2. Reduce negative emotions; RP/C – 7.3. Reduce prompts/cues; RPE - 12.1. Restructuring the physical environment; SC – 6.2. Social comparison; SMB – 2.3. Self-monitoring of behaviour; SMOB – 2.4. Self-monitoring of outcome(s) of behaviour; SS(E) – 3.3. Social support (emotional); SS(P) –3.2. Social support (practical); SS(U) – 3.1. Social support (unspecified); ST – 15.4. Self-talk; VPaC - 15.1. Verbal persuasion about capability; VC - 16.3. Vicarious consequences

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Supplement 5. Intervention and participant characteristics, as well as method of assessment that did not significantly contribute to intervention efficacy

Variable	SMD/b	CI, 95% (lower)	CI, 95% (upper)
Theory use:			
Theory use score (overall, TCS)	0.13	-0.01	0.27
Theory mentioned	0.46	-0.23	1.15
Behaviour Change Techniques:*			
Self-monitoring of behavior	0.49	-0.04	1.03
Information about health consequences	0.50	-0.05	1.06
Social support (emotional)	0.92	-0.08	1.92
Instruction on how to perform a behavior	0.51	-0.11	1.13
Social support (unspecified)	0.53	-0.19	1.25
Demonstration of the behavior	0.37	-0.39	1.12
Feedback on behavior	0.31	-0.77	1.38
Problem solving	0.05	-0.92	1.02
Monitoring outcome(s) of behavior by others without feedback	0.32	-0.92	1.56
Behavioral contract	0.30	-0.93	1.53
Biofeedback	0.50	-1.01	2.01
Review behavior goal(s)	0.18	-1.08	1.43
Reduce negative emotions	0.07	-1.17	1.30
Information about emotional consequences	0.04	-1.47	1.56
Vicarious consequences	0.23	-1.47	2.39
Self-talk	0.04	-1.48	1.55
Social comparison	0.02	-1.55	1.60
Behavioral experiments	0.21	-1.93	2.34
Distraction	0.21	-1.93	2.34
Identification of self as role model	0.21	-1.93	2.34
Reattribution	0.21	-1.93	2.34
Identity associated with changed behaviour	0.23	-1.93	2.39
Non-specific incentive	0.23	-1.93	2.39
Restructuring the physical environment	0.13	-2.01	2.27
Reduce prompts/cues	0.04	-2.22	2.31
Social support (practical)	1.42	-2.22	2.46
Discrepancy between current behavior and goal	-0.14	-2.28	2.01

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Intervention intensity:			
Number of sessions	0.00	-0.01	0.01
Duration, single session (mins)	0.00	0.00	0.01
Intervention contact time (mins)	0.00	0.00	0.00
intervention duration (weeks)	-0.01	-0.04	0.02
Individually delivered	0.30	-0.47	1.06
Setting:			
Home-setting	0.16	-0.66	0.99
Facilitator:			
Telehealth	0.73	-0.79	2.25
Nurse	0.34	-0.38	1.05
HF nurse	0.09	-1.18	1.36
Researcher	0.29	-1.25	1.82
Self-applied	0.21	-1.35	1.76
Lay leader	0.21	-1.93	2.34
Advanced practice nurse	0.23	-1.93	2.39
Cardiac nurse	0.13	-2.01	2.27
Website	0.00	-2.25	2.25
Graduate student therapist (trained)	-0.14	-2.28	2.01
Participant characteristics:			
Age	0.01	0.00	0.01
Males included in the sample, (%)	0.01	0.00	0.02
LVEF, (%)	0.01	0.00	0.02
Physical activity assessment:			
Self-reports	0.68	-0.06	1.41
Accelerometer	0.31	0.07	0.56
Difference in efficacy between trials using accelerometers vs self-reports	-0.32	-1.15	0.51

*(BCTTV1 taxonomy: Michie et al., 2013)

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Supplement 6. Sensitivity analysis: results

EXCLUDED TRIALS	Overall effect	General Approach	Efficacious intervention characteristics
Trials with the education comparator (Boyne et al. 2014; Meng et al. 2016; Freedland et al. 2015; Brodie and Inoue 2005) (Ajiboye et al. 2015)	SMD = 0.31, 95%CI [0.21; 0.40] ***	**Exercise: SMD = 0.34 , 95%CI [0.18; 0.51];** **Remote communication and treatment:** **SMD = 0.42, 95%CI [0.24; 0.60];** Exercise and behaviour change: SMD = 0.21, 95%CI [0.004; 0.41]; Disease Management: SMD = 0.21, 95%CI [-0.03; 0.45]; Self-Management: SMD = 0.23, 95%CI [-0.17; 0.62].	No change in the significance of the effects associated with individual intervention or participant characteristics

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EXCLUDED TRIALS	Overall effect	General Approach	Efficacious intervention characteristics
HF-ACTION trial (O'Connor et al. 2009)	SMD = 0.37, 95% CI: [0.10; 0.63]*	**Exercise: SMD = 0.56, 95%CI [0.18; 0.94];** Remote communication and treatment: SMD =0.41, 95%CI [-0.29; 1.11]; MI: SMD = 0.03, 95%CI [-0.89; 0.94]; **Exercise and behaviour change: SMD = 0.21, 95%CI [-0.59; 1.01];** CBT: SMD = 0.21, 95%CI [-0.91; 1.33]; Disease Management: SMD =0.23, 95%CI [-0.95; 1.41].	Behavioural Practice and Rehearsal * Graded task * Group-based * Centre-based *

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			Social Support (emotional) *
			Social Support (practical) **
			TCS score *
			Monitoring of behaviour by others w/o feedback*
	SMD =	Exercise: SMD =0.36, 95%CI [-0.2; 0.91];	Credible source***
	0.4578	Remote communication and treatment:	Adding objects to the environment ***
High Risk of Bias trials	95%CI	SMD = 0.56, 95%CI [-0.57; 1.7];	Self-monitoring of outcome(s) of
(Ajiboye et al. 2015;	[0.0903	MI: SMD = 0.03, 95%CI [-1.16; 1.21];	behaviour*
Tomita et al. 2008)	0.8252 *	Exercise and behaviour change:	**Self-monitoring of behaviour** *
		SMD = 1.27, 95%CI [0.47; 2.07]***;	**Information about health**
		CBT: SMD = 0.21, 95%CI [-1.38; 1.8];	**consequences** *
		Disease Management: SMD =0.23, 95%CI [-1.39	**Information on how to perform**
		1.85].	**behaviour** *
			Graded tasks *
			Action Planning *
			Goal setting (behaviour) *
			Behavioural Practice and Rehearsal**

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EXCLUDED TRIALS	Overall effect	General Approach	Efficacious intervention characteristics
HF-ACTION trial (O'Connor et al. 2009) and High Risk of Bias trials	SMD = 0.2670 95%CI [0.1549 0.3790 ***	**Exercise: SMD=0.35, 95% CI [0.15; 0.54]*;** **Remote communication and treatment: SMD=0.47, 95%CI [0.24;0.70]*;** MI: SMD=0.03, 95%CI [-0.46;0.52]; **Exercise and behaviour change: SMD= 0.21; 95%CI:[-0.07; 0.49];** CBT SMD= 0.21, 95%CI:[-0.15; 0.57] Disease Management SMD= 0.23, 95%CI:[-0.25; 0.71].	**Nurse** *** **Telehealth**** **Biological Feedback*** Credible source * Self-monitoring of outcomes of behaviour* **Self-monitoring of behaviour** ** **Demonstration of the behaviour** ** **Information about health consequences** ** Graded tasks ** Action Planning ** Goal setting (behaviour)*** Behavioural Practice and Rehearsal***

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Supplement 7. Publication bias: funnel plot